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Via Hand Delivery
Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
236 Massachusetts Avenue, NE
Suite 110
Washington, D.C. 20002

Re: Mobile Satellite Ventures Subsidiary LLC
Written *Ex Parte* Presentation
IB Docket No. 01-185

Dear Ms. Salas:

Mobile Satellite Ventures Subsidiary LLC ("MSV") hereby files an original and two (2) copies of the attached papers, entitled "Analysis of Potential Interference to AMSS Platforms from MSV's Ancillary Terrestrial Base Stations" and "Satellite and Full-Rate GSM Vocoder Issues," for inclusion in the record of the above-captioned proceeding.

Very truly yours,

David S. Konczal

cc: Jim Ball
Paul Locke
Brian Major
Ron Repasi
Tom Tycz
Marcus Wolf

No. of Copies rec'd 0+2
List ABCDE

Analysis of Potential Interference to AMSS Platforms from MSV's Ancillary Terrestrial Base Stations

Prepared by:

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January 29, 2002

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1 INTRODUCTION

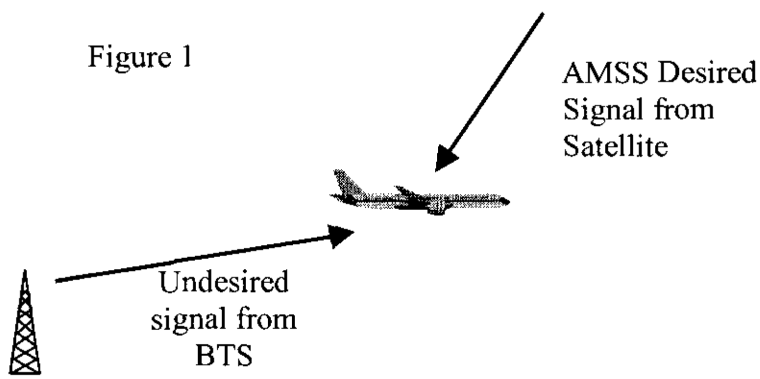
The analysis methodology used on MSV's proposed Ancillary Terrestrial Component (ATC) to evaluate the potential of harmful interference to aeronautical mobile satellite service (AMSS) receivers is presented. As has already been shown by MSV, in its January 10, 2002 presentation to the FCC, AMSS receivers will not experience harmful interference from MSV's ATC, even for the worst case scenario of a plane flying at the minimum allowed altitude (1,000 feet) over an urban area, and that urban area is covered by up to 1,000 ATC base stations. For this worst-case scenario, MSV's analysis, as described in detail below, has shown that the $\Delta T/T$ increase of the AMSS receiver due to the out-of-band emissions from all 1,000 base stations is kept below 6%, while the AMSS receiver maintains a desensitization margin of more than 10 dB.

2 INTERFERENCE PATHS AND MECHANISMS

2.1 Single-Entry Interference

Figure 1 shows the signal and interference paths. The aircraft is receiving signals in the 1545 - 1559 MHz band from a satellite carrying AMSS traffic. The BTS transmits in adjacent portions of the 1525 - 1559 MHz band as well. Some of the power transmitted from the BTS will reach the aircraft. There are two mechanisms whereby that BTS power could interfere with AMSS reception. One mechanism is for spurious emissions from the BTS transmitter that fall within the AMSS channels to raise the noise floor of the AMSS receiver, thus reducing the effective C/N of the desired carriers. The second mechanism is, for the power from the BTS carriers, to overload and cause gain compression in the AMSS receiver. Both mechanisms are addressed below.

Figure 1

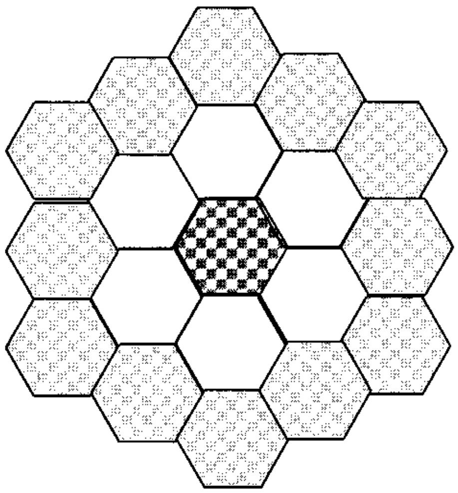


2.2 Multiple Entry Interference

The ATC will comprise a number of BTSs in a number of urban areas. Within each urban area, then, the interference path shown in Figure 1 will be multiplied by the number of BTSs visible from the aircraft. Each BTS will have a distinct signal propagation path to the aircraft that must be analyzed. The net interference will be the sum of interference contributions from each BTS.

For the analysis, MSV has assumed a 1 km coverage radius for each BTS and a maximum of 1,000 BTSs serving a worst-case urban area[1]. Figure 2 shows a portion of an urban coverage area. BTSs will be located approximately in the centers of hexagons representing the coverage of the BTSs.

Figure 2



For the analysis, the aircraft is assumed to be at an altitude of 1000 feet (304 meters) directly above the center cell of such an arrangement of BTSs, and therefore have BTSs extending in all directions. This altitude was chosen because it is the minimum called for in FAA regulations for flight operations over urban areas.

3 ANALYSIS METHOD

The analysis proceeds as follows:

1. Determine the distance from a BTS to the aircraft.

2. From the distance determined in step 1, determine the free-space loss between the BTS and the aircraft.

3. Determine the antenna gain of the BTS toward the aircraft and the aircraft antenna gain toward the BTS. Combine those gains with the free-space loss to determine the total loss from the BTS transmitter to the aircraft receiver.

4. Determine the effect on the AMSS receiver of each BTS transmitter.

[1] The number of base stations per urban area is expected to be significantly less than 1,000.

5. Determine the aggregate effect by aggregating the carrier power from all BTSs and the total BTS spurious power at the aircraft.

6. Determine the significance of the powers calculated in step 5 by comparing them to AMSS receiver characteristics

3.1 Determine the distance from a BTS that is arbitrarily located relative to an aircraft.

Figure 3

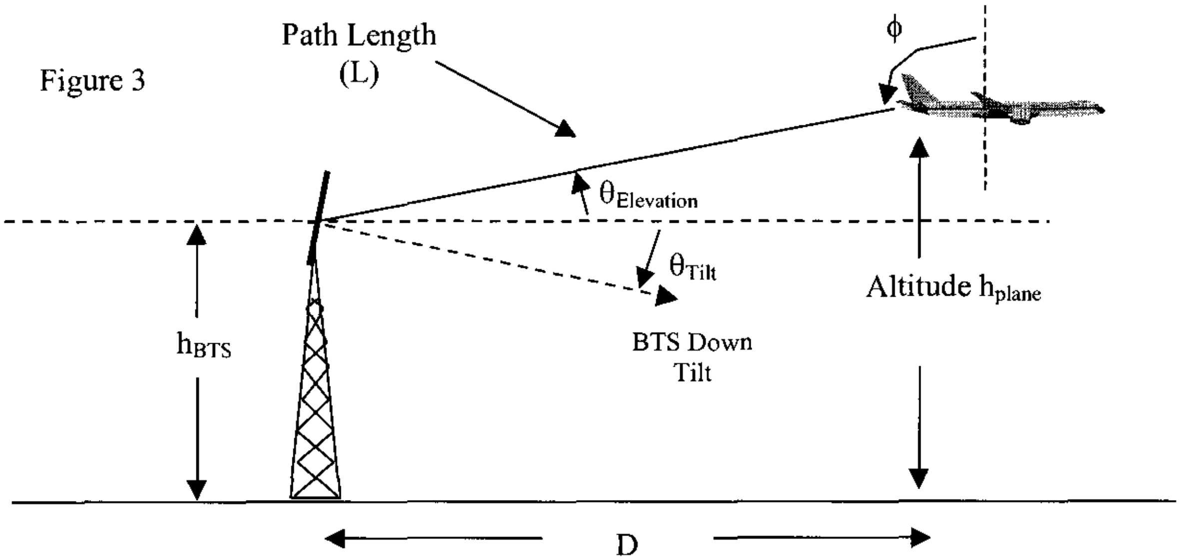


Figure 3 shows the path geometry of a BTS relative to an aircraft. Consider first the path length, L, from the BTS antenna to the aircraft, given the BTS antenna height, aircraft altitude, and horizontal distance between the BTS and the aircraft. The path length L is:

$$L = \sqrt{D^2 + (h_{Plane} - h_{BTS})^2}$$

where:

> L = *Path length (meters)*
>
> h_{BTS} = *Height of the BTS (meters)*
>
> h_{plane} = *Aircraft Altitude (meters)*
>
> *Distance = Horizontal distance from the aircraft to the BTS (meters)*

3.2 Free-Space Loss Determination

Free-Space loss is calculated as:

$$Loss_{Free-space} = 32.4 + 20 * \log(L) + 20 * \log(f)$$

where:

> $Loss_{Free\text{-}space}$ = *free-space loss in dB*
>
> *L = path length in km*
>
> *f = frequency in MHz*
>
> *and log is the common (base 10) logarithm*

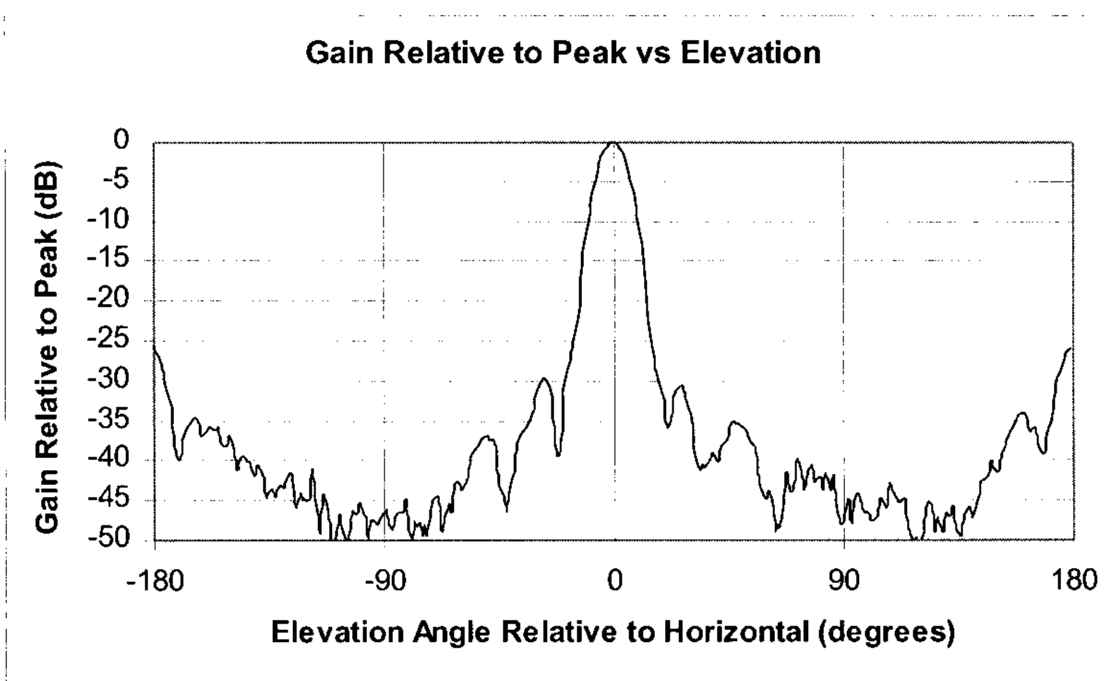
3.3 BTS and Aircraft Antenna Gains

To determine the antenna gains to apply to any given path, the radiation patterns of the antennas must be known. From the radiation patterns and the link geometry, the antenna gains may be determined.

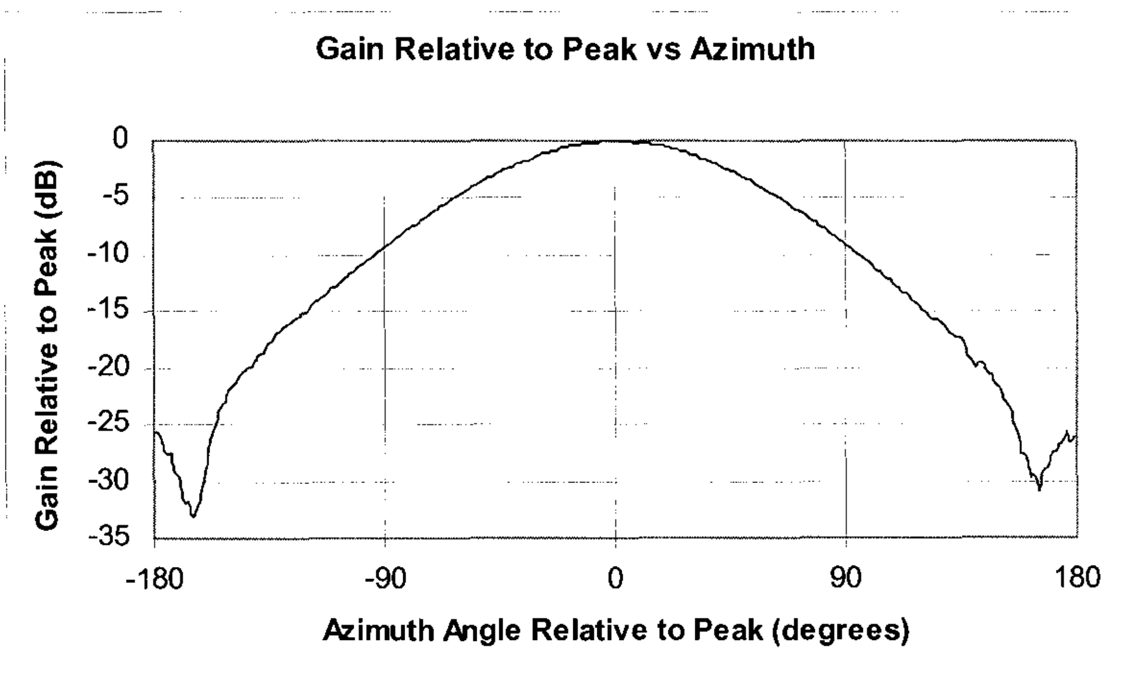
3.3.1 BTS Antenna Patterns

The measured elevation and azimuth radiation patterns, respectively, for MSV's BTS antenna are shown below.

MSV Base Station Antenna Pattern (Elevation Characteristic)



MSV Base Station Antenna Pattern (Azimuth Characteristic)



3.3.2 *Aircraft Antenna Pattern*

The aircraft is assumed to have a high-gain AMSS antenna (12 dBi gain, minimum) that is automatically steered toward the satellite.[2] A detailed pattern is not available to MSV, and so the assumed gain pattern is based on the gain patterns of land mobile satellite antennas of similar gain.

The AMSS antenna is conservatively assumed to have 0 dBi of gain toward BTSs that lie within a ± 30° azimuth sector that is centered about the AMSS antenna pointing direction, and -10 dBi of gain towards BTSs that lie outside of the above sector. Each BTS antenna has a 5° down tilt.

3.3.3 *Calculation of Angle from BTS to Aircraft*

The angle from the BTS antenna to the aircraft can be calculated as (refer to Figure 3)

$$\theta_{Elevation} = \arctan\left((h_{Plane} - h_{BTS}) / D \right)$$

where:

h_{BTS} = *Height of the BTS antenna (meters)*

h_{plane} = *Aircraft Altitude (meters)*

D = *Horizontal distance from the aircraft to the BTS (meters)*

To finally determine the BTS antenna elevation gain toward the aircraft, the down-tilt of the BTS antenna must be taken into account. MSV's design calls for a down-tilt of 5°, which is typical for terrestrial mobile base stations. The down-tilt increases the angular separation between the aircraft and peak BTS gain direction.

3.4 Calculation of the effect on the AMSS receiver of one BTS transmitter.

3.4.1 *AMSS Receiver Characteristics*

In addition to the AMSS antenna characteristic, there are two more parameters required for the analysis. These are the receiver noise floor and the desensitization threshold.

---

[2] "Minimum Operational Performance Standards for Aeronautical Mobile Satellite Service RTCA DO-210D", 2000, RTCA, Incorporated, Washington, DC.

The noise floor can be determined from the G/T of the terminal and the antenna gain. The G/T of an AMSS receiver with a high-gain antenna is -13 dB/K.[3] Since the peak antenna gain is 12 dBi, the noise temperature and thermal noise power density of the receiver may be calculated:

$$T_{Receiver} = -(G/T - G_{Antenna})dBK$$
$$T_{Receiver} = -(-13 - 12)dBK$$
$$T_{Receiver} = 25dBK = 316K$$

$$No_{Receiver} = k + T_{Receiver}$$
$$No_{Receiver} = -(228.6 + 25) = -203.6dBW/Hz$$

Where:

G/T = G/T of the AMSS receiver in dB/K

$G_{Antenna}$ = AMSS Antenna Gain in dBi

k = Boltzmann's constant = -228 dBW/Hz-Kelvin

The desensitization threshold is determined from the ARINC specifications for AMS(R)S platforms. ARINC Characteristic 741, Part 1-9 (November 1997) 2.2.4.2 specifies the gain of the front end (comprising the LNA and diplexer) as 53 dB < G < 60 dB. In the same document, 2.2.4.5 specifies the 1 dB compression point at a minimum front-end output level of 10 dBm. Thus, the worst-case front-end input level leading to desensitization is -50 dBm (or -80 dBW).

3.4.2 BTS Transmitter Characteristics

The following tables show the calculation of radiated spurious power density and effective radiated power density from a BTS site. Each BTS site is assumed to transmit in three sectors and transmit three carriers per sector. The effect on EIRP of multiple carriers per sector is additive, that is, three carriers result in 5 dB (10log(3)) more EIRP than does one carrier. However, the effect of multiple sectors per BTS is not additive. At any given azimuth from a BTS site, the contributions from the threes sectors will vary depending on the azimuth pattern of the BTS antennas. For the measured antenna pattern, the additional effect of three sectors is at most 0.3 dB greater than for one sector.

[3] *ibid.*

Parameters Relating to BTS Spurious EIRP Density

BTS Spurious EIRP Density/Carrier	-101.9	dBW/Hz
Power Increase from Using 3 Sectors per site (120 degree sectors)	0.3	dB
Carriers per BTS Sector =	3	--
Voice Activity Reduction =	-4	dB
Average Power Reduction = (due to closed-loop power control)	-6	dB
Polarization Discrimination =	-8	dB
Total Spurious EIRP Density per BTS =	**-114.8**	**dBW/Hz**

Parameters Relating to BTS Carrier EIRP

BTS Maximum EIRP per carrier	19.1	dBW
Power Increase from Using 3 Sectors per site (120 degree sectors)	0.3	dB
Carriers per BTS Sector =	3	--
Voice Activity Reduction =	-4	dB
Average Power Reduction = (due to closed-loop power control)	-6	dB
Polarization Discrimination =	-8	dB
Total EIRP per BTS Site	**6.2**	**dBW**

3.4.3 AMSS Receiver Noise Floor Increase from BTS Transmissions

All necessary parameters have now been determined. BTSs are added in hexagonal rings as show in figure 2. For each ring, the average distance from BTSs in that ring to the aircraft is determined. Then, for each ring, the subtotal of BTS radiated power at the aircraft is determined and finally, the subtotals are combined to determine the total BTS power received at the aircraft.

For each ring:

$$Poi_{RcvdSpurious} = Po_{BTS\_Spurious} + \Delta Gt_{BTS} + 10 * \log(Number\_of\_BTSs\_in\_ring)$$
$$- FSL(Frequency, Distance) + Gt_{Aircraft}$$

Where:

$Poi_{Rcvd\ Spurious}$ = *Power density at the aircraft receiver from the ith ring of BTS (dBW/Hz)*

$Po_{BTS\_Spurious}$ = *Total Effective Spurious EIRP Density per BTS =-114.8 dBW/Hz*

DGt_{BTS} = *Gain of BTS antennas in the ring toward the aircraft relative to peak BTS antenna gain (dB)*

*Number of BTSs in ring = number of BTSs in the ith ring = 1+ 6 * i*
for 1000 BTs, i= 0, 1, ...17, 18

FSL = Free space loss at 1545 MHz and the average distance from BTSs in the ith ring to the aircraft (dB)

$Gt_{Aircraft}$ =*Average gain of aircraft antenna toward the ring using the assumptions of section 3.3.2 (dBi)*

The preceding equation calculates the received spurious power density for each of the rings, and the next step is then to total it over the first 19 rings, which contain a total of 1027 BTSs.

The ΔT/T resulting from the BTS spurious power is then calculated as:

$$\Delta T/T = 10^{(.1*(Po_{RcvdSpurious} - No_{Receiver})}$$

Where:

$Po_{RcvdSpurious}$ = *Total received spurious power at the AMSS receiver (dBW)*

$No_{Receiver}$ = *Thermal noise density at AMSS receiver (see section 3.4.1) (dBW)*

Using all of the above, we find that the total ΔT/T of the AMSS receiver is less than 6% for an aircraft flying at the minimum altitude of 1000 feet.

3.4.4 AMSS Receiver Desensitization Effect from BTS Transmissions

The total BTS carrier power at the AMSS receiver can be calculated using a similar process to that used for the spurious interference analysis.

For each ring:

$$Pi_{RcvdCarrier} = P_{BTS} + \Delta Gt_{BTS} + 10 * \log(Number\_of\_BTSs\_in\_ring) - FSL(Frequency, Distance) + Gt_{Aircraft}$$

Where:

$Pi_{Rcvd\ Carrier}$ = *BTS carrier power at the aircraft receiver from the ith ring of BTSs (dBW)*

P_{BTS} = *Total Effective Carrier EIRP per BTS =6.2 dBW*

ΔGt_{BTS} = *Gain of BTS antennas in the ring toward the aircraft relative to peak BTS antenna gain (dB)*

*Number of BTSs in ring = number of BTSs in the ith ring = 1+ 6 * i*
for 1000 BTs, i= 0, 1, ...17, 18

FSL = Free space loss at 1545 MHz and the average distance from BTSs in the ith ring to the aircraft (dB)

$Gt_{Aircraft}$ =*Average gain of aircraft antenna toward the ring using the assumptions of section 3.3.2 (dBi)*

The preceding equation calculates the received spurious power density for each of the rings, and the next step is then to total it over the first 19 rings, which contain a total of 1027 BTSs. The total received power at the MSS is -65.4 dBm for an aircraft flying at the minimum altitude of 1000 feet. That power level is more than 10 dB below the desensitization threshold of -50 dBm.

4 CONCLUSION

For the worst-case scenario of a plane flying over an urban area at 1000 feet, no harmful interference will be caused to AMSS receivers.

SATELLITE AND FULL-RATE GSM VOCODER ISSUES*

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January 29, 2002

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* A White Paper Complement to Mobile Satellite Ventures' January 10, 2002 Presentation Before the Federal Communications Commission

THE VARIABLE RATE VOCODER CONCEPT FOR TERMINALS IN ATC MODE

Inmarsat has claimed that the average level of shielding from MSV's terminals, in terrestrial mode, is too low to provide protection. MSV maintains that shielding from buildings, vehicles and other obstructions is more than adequate -- if for no other reason than satellite service would otherwise be acceptable in urban areas. Other factors also have a significant impact on the interference analysis, including satellite antenna discrimination, polarization isolation, and power control. Another important factor is the use of variable rate vocoders to selectively reduce the effective output power of a handset as needed. MSV's use of this technique, already commonly deployed in CDMA systems (terrestrial and satellite) effectively guarantees an additional 7.4 dB of average power reduction on the transmissions of each terminal operating in ancillary terrestrial mode. This reduction is in addition to the other factors, and comes at no extra cost to MSV's ancillary terrestrial network or terminals. The technique is already in use in CDMA networks for reducing intra-system interference in hot-spot areas, thus maximizing system capacity.

The technique is based on the idea of using a variable rate vocoder, or a set of vocoders each with a different compression rate, whereby a lower rate vocoder (higher voice compression) is allocated to the user as a function of system loading. For example, for a CDMA system, as system loading increases, the vocoder rate is reduced keeping the co-carrier interference level substantially invariant as more users are added onto a given carrier.[1]

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[1] As the vocoder output rate is reduced (voice compression rate is increased), the number of information bits that must be transmitted per unit of time is reduced and, thus, the desired energy level per information bit can be satisfied with a reduced transmitter output power level. Reducing the transmitter output power

Each terminal of MSV's next generation system will have several vocoders built into it. This is necessary since in the satellite mode (given the power and spectral constraints of the satellite link) a lower rate vocoder must be used than when the terminal is communicating terrestrially. A full-rate GSM vocoder may be used, for example, when the mobile is engaged terrestrially while a quarter-rate GSM vocoder (or lower) may be used during satellite communications.

Every active MSV mobile (whether it is communicating via the satellite or the ancillary terrestrial network) will periodically report to the system a set of parameters including location, transmit power level, received signal level, received signal quality, the strength of broadcast signals of near-by cells (in order to assist the system to perform inter-cell hand-over), etc… The transfer of such information, from an active mobile to the system, occurs very frequently and periodically via established in-band signaling protocol ("SACCH" or even "FACCH" messaging). Therefore, at any given time, the MSV system will know the output power level of each one of its active terminals.

A terminal that is terrestrially engaged in voice communications will be allocated the highest rate vocoder, and, will thus, be operating in full-rate GSM mode. However, when its output power, as reported to the system by the terminal, exceeds an upper bound (say -10 dBW), that terminal will, via fast in-band signaling, be commanded to switch over to quarter-rate GSM mode (equivalent to satellite-mode). In this mode, that terminal now needs to transmit only one GSM burst once every 4 GSM frames (see Figure 1).

If the vocoder rate reduction were exactly a factor of four in going from full-rate GSM to quarter-rate GSM, the average power reduction benefit would be 6 dB. In

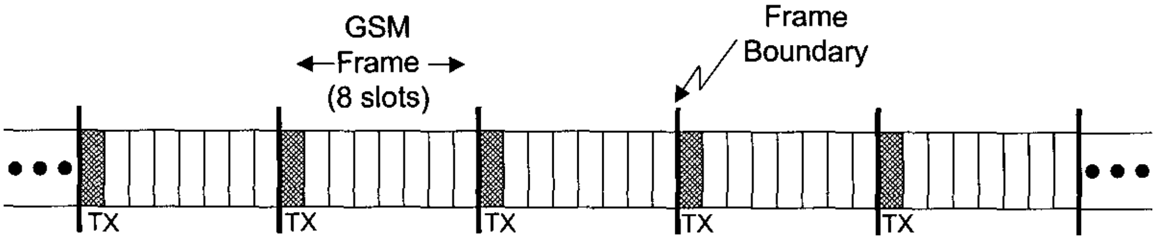
---

level, in turn, reduces the potential for co-carrier interference of users who are sharing resources on the same carrier and are relying on "code orthogonality" for separation.

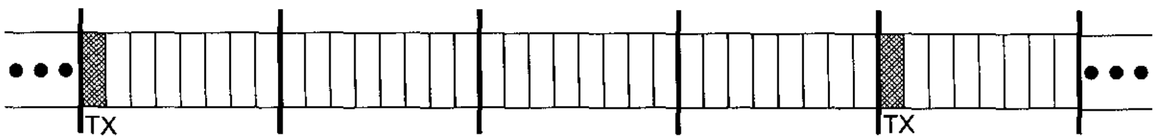
practice however, the vocoder rate reduction (in switching from the full-rate GSM mode to the quarter-rate GSM mode) exceeds a factor of four thus affording more coding and thus higher average power reduction. Thus, the average power reduction is 7.4 dB.

In typical applications, lower rate vocoders are used to increase power and/or spectral efficiency. In the context of MSV's ancillary terrestrial operations, the use of a lower (than full-rate GSM) rate vocoder will only be used to increase the power efficiency of the mobile terminal, thus minimizing co-channel interference.

FIGURE 1: GSM Frame Utilization for Voice Communications



a) A mobile transmitting in full-rate GSM mode



b) A mobile transmitting in quarter-rate GSM mode (satellite mode)

The first half of the figure (part (a)) assumes that a terminal is in ancillary terrestrial mode and is transmitting per full-rate GSM protocol. As shown, the terminal transmits one (information) burst per GSM frame, with each burst transmission occupying one of the eight available slots of the frame. In full-rate GSM mode, short segments of voice are digitized (at a rate of 64 kbps) and then compressed using a ~13 kbps vocoder.

The second half of the figure (part (b)) illustrates what the transmission pattern of the same terminal (shown in part (a)) would be after the terminal has been switched to ¼ -rate GSM mode. In ¼ -rate GSM mode, short segments of voice are digitized (as in full-rate GSM mode) but then are compressed more using (for example) a 2.4 kbps vocoder. As such, the channel information rate is reduced, relative to full-rate GSM, by (at least) a factor of four, e.g. the number of information bits that must be transmitted per unit of time is reduced by (at least) a factor of four. As a direct consequence, a terminal transmitting in quarter-rate GSM mode, needs to only transmit one information burst once every four GSM frames (as shown in part (b) of the above figure). Everything else being equal, this means that the average power transmitted by the terminal is now 6 dB lower than when transmitting in full-rate GSM mode. When the compression factor in switching from full-rate GSM to ¼ -rate GSM exceeds four, additional coding bits can be inserted, increasing the coding gain, and providing additional average power reduction benefits.

In general, as the vocoder output rate is reduced (i.e. from 13 kbps to 2.4 kbps) voice quality degrades. However, vocoder technology continues to improve and today there are commercially available low-rate vocoders (2.4 kbps by DVSI) with Mean Opinion Score (MOS) values of about 3.5 (5 is best; the full rate GSM vocoder has a MOS of ~3.85).